Using EQuIS and ArcGIS for Environmental Decision Support at a Large Oil Refinery

David B. Towsey, Scot D. Weaver, Brett R. Milburn

Abstract Environmental site characterization activities at a large industrial facility can be a complex and costly endeavor. The high volume of data generated from groundwater sampling, soil sampling and other field activities is often difficult to manage. As computer technologies have advanced, new data management and data visualization tools have enabled engineers and geologists to efficantly conduct these site characterization activities. This paper will discuss the use of ArcGIS and EarthSoft's EQuIS Chemistry and EQuIS Geology databases as tools for the management and visualization of environmental data at a large oil refinery.

Introduction

Langan Engineering and Environmental Services (Langan) was retained to provide technical oversight and strategic direction for an ongoing groundwater remediation program at a large oil refinery. Existing remedial systems included a series of product recovery wells to recover light non-aqueous phase liquid (LNAPL). In addition, groundwater and product recovery is ongoing from three major aquifers underlying the facility. Langan's initial tasks have focused on development of a long-range strategic management plan for evaluating and modifying, as necessary, the groundwater remediation program. Primary objectives include establishing priorities based on protecting potential environmental receptors and identifying cost-effective methods of improving ongoing product recovery efforts. Product mapping and recoverability testing is being performed to determine appropriate methods to implement. Four primary data collection activities are being performed in support of a site-wide characterization of environmental conditions. These activities include groundwater monitoring, LNAPL monitoring, geology characterization, and groundwater analytical sampling.

The management of data collected at the site, both historic and current, presented the greatest challenge for developing a site characterization model. Langan chose to utilize a third-party environmental database management system for data warehousing. Using a commercial, off-the-shelf product rather than developing an in-house solution resulted in the immediate availability of a proven and tested solution for a fraction of the cost of other alternatives. EQuIS was chosen as the data management system because of its ease of use, low cost and compatibility with other software packages. ArcGIS was selected as the visualization tool because of ease of use and the additional extensions that provide many different data visualization options.

LNAPL Monitoring

The main objective of the LNAPL monitoring is to develop a site conceptual model that will help in determining the nature and extent of free product within the boundary of the refinery. This includes modeling the LNAPL data to determine the possible sources of free product occurrence, as well as any potential receptors that could possible be affected by free product, both on and offsite.

The major challenge that was faced with the LNAPL monitoring activity was the large volume of historical LNAPL data dating back to 1985 that had to be transferred from Microsoft Excel tables and an existing database into the data management system. As is the case with any historical data migration, this task was labor intensive and involved extensive review of the reference value lists and relationships between data tables. Furthermore, it was necessary to ensure that the inherent differences typical of historical data could be resolved sufficiently to allow the data to “play by the rules” of a robust data structure that enforces referential integrity.

The end result of this task was an up-to-date central database with all LNAPL measurements from 1985 to the present time. This allowed for easy data querying and reduced the likelihood of errors when using the data.

ArcGIS was used to visualize the LNAPL data in the form of 2D and 3D plumes which showed the vertical and horizontal extent of LNAPL occurrence at the facility. This task was accomplished by querying the LNAPL data located in the database within the ArcGIS environment and visualizing the plumes using the ArcGIS Spatial Analyst and 3D Analyst extensions.

LNAPL thicknesses and depth measurements were modeled using geospatial statistical outputs such as kriging and inverse distance weighted interpolation within the Spatial Analyst Extension. This created a grid of LNAPL thickness values which was then contoured or brought directly into the ArcGIS 3D Analyst Extension for visualization.

Using ArcGIS to model the LNAPL allowed us to complete this task much quicker and cost effectively and provided the tools necessary to visualize the data.

Groundwater Monitoring

Groundwater contouring of the three on-site aquifers (upper, middle and lower) was an important aspect in developing the site conceptual model. The contouring of the groundwater is essential in determining the direction in which groundwater flows across the site and in determining where the remediation of dissolved and free product should take place onsite.

A similar challenge was faced with groundwater monitoring data as with the LNAPL data. Because the groundwater data came from disparate sources in various formats, a nontrivial effort was required to collect both historic and current data, review the quality of the historic data in comparison to the current data, and prepare all of the groundwater information to be loaded into the data management system. Software tools made the actual checking and loading of the data straightforward; however, the very nature of a historical data migration implies a manual review effort of some extent.

The end result of this task was an up to date central database with all groundwater monitoring measurements from 1985 to the present time. This allowed for easy data querying and reduced the chances for errors when using the data.

ArcGIS was used to visualize the groundwater data in the form of 2D contours which showed the groundwater elevations at the facility. ArcGIS facilitated visualization of the groundwater data with other spatial data such as site topography and generalized geologic data to get a better understanding of groundwater flow throughout the site.

Groundwater Analytical Sampling

In addition to assisting in the development of the site conceptual model, the analytical concentration modeling of benzene, toluene, ethyl-benzene and xylenes, commonly referred to as BTEX, methyl tertiary butyl ether (MTBE), and tertiary butyl alcohol (TBA) is being performed to determine the areas onsite that are considered a priority for remediation. The state agency which provides regulatory oversight also requires the monitoring of analytical concentrations onsite to assess the need for further remediation efforts. Depending on the results of the analytical sampling data which is collected semi-annually, we can also determine which areas are a priority to perform more detailed remedial investigations and activities. Lastly, analytical concentration modeling allows us to assess areas of increased or decreased concentrations over time.

The historical analytical data that were provided presented a few complications due to the large quantity of data in a Microsoft Excel format. The single biggest complication was giving each sample a unique location ID since each location had multiple samples over time. The second biggest challenge was finding and/or determining the data that was missing from the various historical documents and files. Data such as a specific location ID, lab sample ID, sample type, lab method name, CAS number, chemical name, and sample matrix were commonly not included.

ArcGIS was used to visualize the analytical data in the form of 2D and 3D plumes which showed the vertical and horizontal extent of analytical concentrations at the facility. This was accomplished by using EQuIS for ArcGIS. This tool allowed us to query the analytical data in many different ways. The data was queried to show concentrations that exceeded regulatory requirements, analytical compound concentrations that are correlated with other compounds such as MTBE and TBA, and analytical compounds at specific wells.

The ability to query the analytical data with multiple criteria provided insight into the extent and nature of the contamination at the property. When combined with other data such as the LNAPL extent, a clear picture of the site conceptual began to develop.

Geologic Characterization

The purpose of modeling the geology of the site is to help us better understand and grasp the knowledge of how groundwater and product flows across the site. This will help us better understand which areas of the site could possibly be source areas or receptors of SPL and groundwater contaminants. Knowing the geology of the site also allows us to determine where new wells may be installed and at what depth the wells may be screened.

Getting the geology data into the database was a time consuming challenge because there was no previous digital file created. The procedure for importing the geology data consisted of paging through a book of well information and filling in the required columns of data in a comma separated value file which was later imported in EQuIS. This task allowed us to query geologic data and visual trends within the data. We were able to find historic wells that were screened improperly, find areas of the site that had data gaps, and develop a soil sampling plan based on these data gaps. Putting this data into a database also allowed us to use the data in other software packages thus leveraging the data for a variety of purposes. As an example, we were able to create boring logs from the database using third party software that interfaced with EQuIS. This saved us time and money because we did not have to re-type the data into the boring log program.

The data management system chosen helped solve the problem of storing a vast amount of current and historical groundwater, product thickness and analytical information for a large oil refinery. In addition to solving the problem of how to centrally store all of the historical information, the database also allowed us to store well construction and geologic information and then visualize this data using an ArcGIS interface. In turn, the overall goal of saving our client time and money was achieved.

The geologic characterization data combined with well construction information provided a final piece to the site characterization puzzle.

Conclusion

ArcGIS and EQuIS played a large role in the Site Conceptual model development. The benefit of having all of our data in a central database that interfaces with ArcGIS allows us to save our client money by decreasing the amount of time that it takes us to manage and view our data. Having all of the data in a central database eliminated the possibility for data errors and allowed us to pull the data into the ArcGIS environment quickly.

The next major step in the development of our database is to complete the task of entering all geologic strata information, well construction information, and product fingerprint analysis data. Once the remaining data is completely entered into the database, the only future work remaining will be regular maintenance, the addition of sampling event data and the addition of any newly installed wells information.

D. B. Towsey
Langan Engineering and Environmental Services, Inc., 500 Hyde Park, Doylestown, PA., 18901, USA
email: dtowsey@langan.com

S. D. Weaver
EarthSoft, Inc., 10820 South 800 East, Paradise, UT., 84328, USA
email: sweaver@earthsoft.com

B. R. Milburn

Langan Engineering and Environmental Services, Inc., 500 Hyde Park, Doylestown, PA., 18901, USA
email: bmilburn@langan.com